

CHAPTER 2

PNEUDRAULIC LINES

RIGID TUBING

Characteristics. Rigid tubing assemblies are made of aluminum alloy, stainless steel, or copper. Some air systems aboard aircraft have copper tubing. Two aluminum alloys are commonly used: 5052 and 6061. Alloy 5052 may be used for lines carrying pressures up to 1,500 psi; alloy 6061 may be used for pressures up to 3,000 psi. As a general rule, exposed lines and lines subject to abrasion, intense heat, or extremely high pressure are made of stainless steel.

The tubing used to produce rigid tubing assemblies is sized by its outside diameter (OD) and wall thickness. Outside diameter sizes are in sixteenth-of-an-inch increments, the number of the tube indicating its size in sixteenths of an inch. For example, number 6 tubing is 6/16 or 3/8 inch, number 8 tubing is 8/16 or 1/2 inch, and so forth. Wall thickness is specified in thousandths of an inch. Most aircraft maintenance manuals contain a table which lists the original material and acceptable substitutes and gives the wall thickness for each.

Damage. Nicks and scratches on tubing can be reduced by using care. Most damage of this kind occurs because of careless handling of tools during aircraft maintenance. Any dent less than 20 percent of the tubing diameter is not objectionable unless it is on the heel of a short-bend radius. A nick no deeper than 15 percent of wall thickness of aluminum, aluminum alloy, copper, or steel tubing may be reworked by burnishing with hand tools; any nicks in excess of 15 percent of wall thickness should be rejected. Nicked tubing is not only weaker due to internal pressure, but it must be burnished out to reduce a notch effect. If nicks are not burnished out, stress concentration under vibration will cause the tubing to become weak and break at nicked points.

Burnishing removes notches by removing the surrounding material. Burnishing is not allowed in the heel of bends where material has already been stretched thin during forming. Tubing which is nicked in a bend should be replaced if it is carrying over 100 psi pressure. For tubing carrying pressures of 100 psi or less, a nick no deeper than 20 percent of wall thickness of aluminum, aluminum alloy, copper, or steel tubing may be reworked by burnishing with hand tools. When tubing is used for fluids at atmospheric pressure or less, the bursting strength of the tubing is unimportant; however, it must be leak-tight at all times. Dents can be removed from tubing by drawing a bullet through the tubing. The diameter of the bullet must be equal to or slightly less than the inside diameter of the tubing.

All tubing is pressure-tested before installation and is designed to withstand several times the operating pressure which it will be subjected

to. Generally, bursting or cracking of a tube is due to improper installation, damage caused by collision with an object, or excessive vibrations. When tubing fails, the cause should be determined. Replacements should be of the same size and material as the original, or an acceptable substitute listed in the applicable maintenance manual may be used.

Repairs. A damaged line should be carefully removed so that it may be used as a template or pattern for the replacement item. If the old piece of tubing cannot be used as a pattern, make a pattern key by placing one end of a piece of soft wire into one of the fittings where the tube is to be connected; then form the bends that are necessary to place the opposite end of the wire into the other connection. When the template satisfactorily spans the area between the fittings, it can be used as a pattern to bend the new tube.

Select a path with the least amount of bend. This reduces flow loss and simplifies bending. If possible, use a path with all bends in the same plane. Never select a path that requires no bends; tube cannot be cut or flared accurately or installed satisfactorily without bends. Bends absorb vibration and permit the tubing to expand or contract under temperature changes. If the tube is small (under 1/4 inch) and can be hand-formed, casual bends may be made. If the tube must be machine-formed, definite bends must be made to avoid a straight assembly. All bends must start a reasonable distance from the end fittings. This is because the sleeves and nuts must be slipped back along the tube during the fabrication of flares and during inspections. In all cases, the new tube assembly should be so formed before installation that pulling or deflecting the assembly into alignment by the coupling nuts is not necessary.

The objective in bending the tube is to obtain a smooth bend without flattening the tube. Usually a tube is bent with a tube bender; only in extreme emergencies would a tube be bent without using a hand-held or mechanical bending tool. A hand-held tube bender has a hand-clip handle, radius block, and slide-bar handle. The two handles act as levers to provide the mechanical advantage necessary to bend the tubing. A mechanical tube bender is issued as a kit. The kit contains the necessary equipment and instructions to bend tubing from 1/4 to 3/4 inch in diameter. This tube bender is used with metal tubing such as aircraft high-strength stainless steel.

Rigid tubing is repaired by replacing fittings and splicing sections of tubing using the permaswage repair procedure. Repairs may be done on or off the helicopter. The basic repair method is to mechanically swage the permaswage fitting onto the tube with a hydraulically operated tool. Fittings are permanent unions, elbows, tees, and crosses; flared, flareless, and separable sleeves; and combinations of permanent and threaded fittings.

The portable hydraulic power supply provides pressure required to operate the swaging tool. MIL-H-5606 fluid is fed to the tool through a 1/4-inch quick-disconnect, high-pressure hose. A swaging pressure of 5,500 psi may be applied to all tubing sizes and materials by manually operating the hand pump or using air-to-hydraulic fluid pressure from a 60- to

100-psi shop air source. A remote control air switch is provided to activate the air-to-hydraulic fluid valve. To prevent tool damage, keep the swaging pressure level from reaching more than 5,500 psi by using a pressure-relief valve. After swaging is finished, reduce the pressure to zero by turning the manual four-way selector valve to EXHAUST.

To repair damaged tubing, use the following procedures:

NOTE: Repair procedures are typical for all separable and permanent fittings.

1. Determine the type of repair to be performed by using the chart in Figure 2-1.

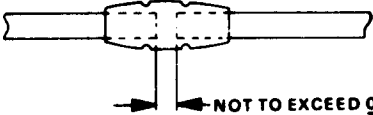

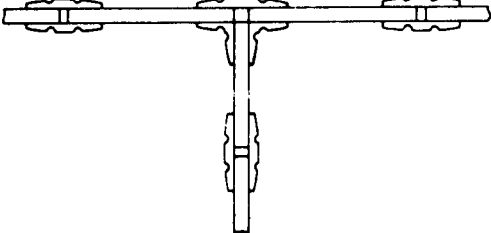
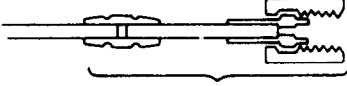
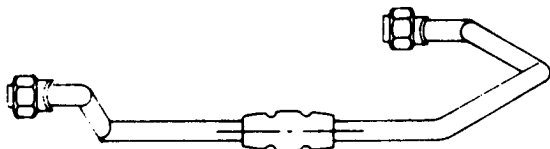
TYPE OF FAILURE	REPAIR METHOD
1. PINHOLE LEAK OR CIRCUMFERENTIAL CRACK IN TUBING.  <p>NOT TO EXCEED 0.30 INCH</p>	1.a. MAKE 1 OR 2 CUTS AS NECESSARY TO REMOVE DAMAGED SECTION. IF 2 CUTS ARE REQUIRED, THE DISTANCE BETWEEN THEM SHALL NOT EXCEED 0.30 INCH. IF THIS MEASUREMENT IS EXCEEDED, GO TO REPAIR METHOD 2. b. SWAGE ONE PERMANENT UNION IN TUBE SECTION UNDER REPAIR.
2. LONGITUDINAL CRACK IN TUBING (CRACK LENGTH IN EXCESS OF 0.30 INCH).  <p>NEW SECTION ORIGINAL TUBING</p>	2.a. MAKE 2 CUTS TO REMOVE DAMAGED SECTION. b. REMOVE DAMAGED SECTION AND DUPLICATE. c. SWAGE REPLACEMENT SECTION INTO TUBING UNDER REPAIR USING TWO PERMANENT UNIONS.
3. LEAKING TEE OR ELBOW (PERMANENT TUBE-CONNECTION TYPE).  <p>NEW TUBE-END ASSEMBLY</p>	3.a. CUT OUT DEFECTIVE TEE OR ELBOW. b. DUPLICATE TUBING SECTIONS FOR EACH BRANCH. c. SWAGE SPLICE SECTIONS TO TEE OR ELBOW. d. CONNECT EACH SPLICED SECTION TO TUBING UNDER REPAIR USING A TUBE-TO-TUBE UNION.
4. LEAKING SEPARABLE END FITTING.  <p>NEW TUBE-END ASSEMBLY</p>	4.a. CUT TUBING TO REMOVE DEFECTIVE FITTING. b. MAKE UP SPLICE SECTION c. SWAGE APPROPRIATE END FITTING TO END OF SPLICE SECTION d. CONNECT NEW END FITTING TO MATING EQUIPMENT CONNECTION, TORQUING NUT AS REQUIRED. e. SWAGE 1 PERMANENT UNION CONNECTING NEW TUBE-END ASSEMBLY TO TUBE SECTION BEING REPAIRED.

Figure 2-1. Troubleshooting procedures to repair tubing.

WHEN USING ANY OF THE FOUR REPAIR METHODS, (1 THROUGH 4) REFER TO THE FOLLOWING PROCEDURES:



1. BEFORE CUTTING THE TUBE, USE THE MARKING PEN AND A RULER TO DRAW A LINE PARALLEL TO THE TUBE RUN ACROSS THE SECTION TO BE CUT.
2. CUT THE TUBING.
3. IF A TUBE END IS TO BE REPLACED, PLACE THE LINE IN THE SAME LOCATION ON THE NEW TUBE AS THE TUBE SECTION THAT HAS BEEN REMOVED.

CAUTION

DO NOT FORGET TO PLACE TUBE INSERTION MARK ON ALL TUBE ENDS.

4. DRAW A LINE ACROSS THE FITTING.
5. INSTALL THE TUBE RUN AND LOCATE THE FITTING. FINGER TIGHTEN ANY END FITTINGS. (ONE END OF THE FITTING MAY BE SWAGED ON THE BENCH, IF POSSIBLE.)
6. PLACE THE SWAGE TOOL ON THE FIRST END BEING SWAGED, LINING UP THE LINE ON THE TUBE END BEING SWAGED WITH THE LINE ON THE FITTING.
7. REPEAT THIS STEP WITH THE OTHER ENDS TO BE SWAGED.
8. TIGHTEN ANY END FITTINGS TO THEIR PROPER TORQUE VALUE.

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Figure 2-1. Troubleshooting procedures to repair tubing (continued).

2. Select applicable repair kit from the list in Figure 2-2.

MAJOR EQUIPMENT COMPONENTS:	FOR USE WITH TUBE SIZES:
Tube Repair Kit D12102C-01-01	3/16, 1/4, 5/16, and 3/8 inch
Tube Repair Kit D12102C-06-06	1/2, 5/8, and 3/4 inch
Tube Repair Kit D12102C-09-04	1, 1-1/4, and 1-1/2 inches

Figure 2-2. Repair kits.

3. Determine correct tube and fitting clearances (see Figure 2-3).

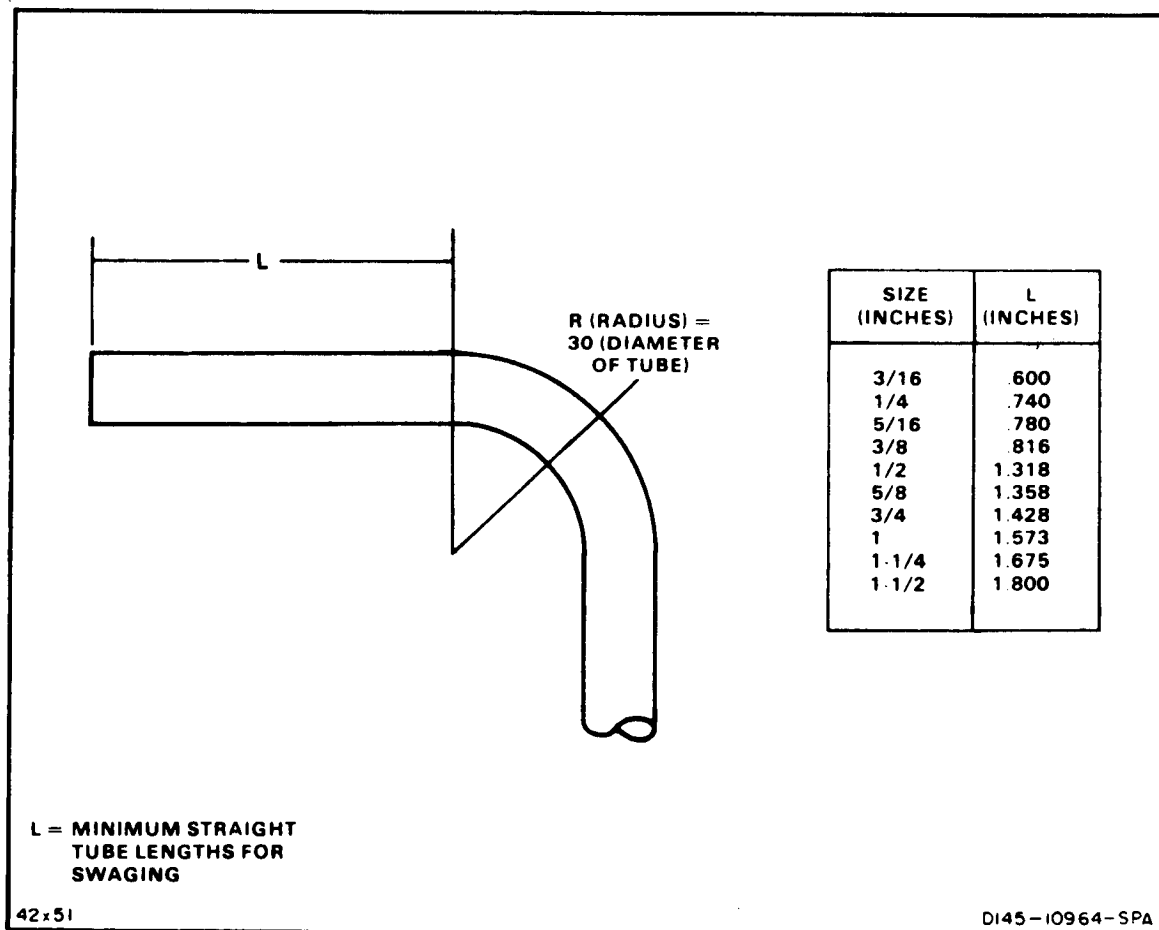


Figure 2-3. Tube and fitting clearances.

Then cut the tubing. When cutting the tubing, the objective is to produce a square end that is free from burrs. Tubing may be cut with a tube cutter (Figure 2-4) or with a fine-tooth hacksaw (not shown). To use the tube cutter correctly, place the tube in the cutter with the cutting wheel at the point where the cut is to be made. Tighten the adjusting knob so light cutter pressure can be applied on the tube; then rotate the cutter towards its open side. As the cutter is rotated around the tube, continue to apply light pressure to the cutting wheel by intermittently tightening the knob. Too much pressure applied to the cutting wheel at one time may damage the tubing or cause too many burrs. After the cut is completed, remove all burrs inside and outside of the tube. Then clean the tube to make sure that no foreign particles remain.

If a tube cutter is not available, a fine-tooth (32 teeth per inch) hacksaw may be used. After cutting the tubing with a hacksaw, remove all saw marks by filing. After filing, remove all burrs and sharp edges from inside and outside of the tube. Then clean out the tube and make sure that

no foreign particles remain. Refer to Figure 2-4 to complete steps 4 through 9 below.

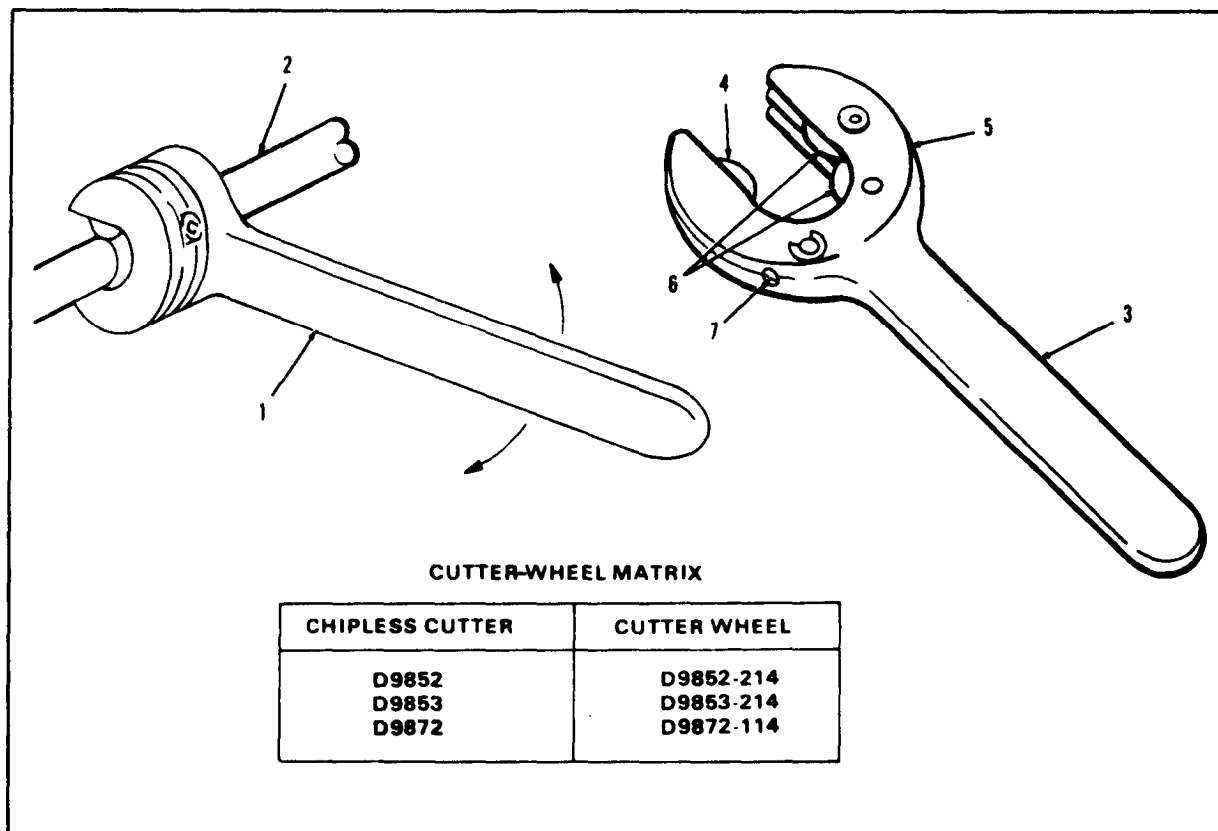


Figure 2-4. Tube cutter and cutter-wheel matrix.

CAUTION

OVERTORQUING SOFT TUBING WILL CAUSE A LARGE BURR.
OVERTORQUING HARD TUBING CAN DAMAGE THE CUTTER WHEEL.

4. Select the appropriate chipless cutter (1) for the size of the tube (2). Check that the handle (3) is operating freely and that the cutter wheel (4) is clear of the cutter-head opening. Make sure the cutter is clean and properly lubricated. (See step 3 for correct tube and fitting clearance.)
5. Rotate the cutter head (5) to accept the tube (2). Locate the cutter (1) in cutting position on the tube. Center the tube on the two rollers (6) and the cutter wheel (4).
6. Tighten the drive screw (7) until the cutter wheel (4) makes light contact on the tube (2). Tighten the screw an additional 1/8 to 1/4 turn. Do not overtorque.

7. Rotate the handle (3) through the arc of clearance until rotation eases noticeably.
8. Tighten the screw (7) an additional 1/8 to 1/4 turn. Repeat step 7 until the cut is complete.
9. Check the remaining section of tube (2). The cut should be square to the tube centerline within one-half of a degree.

After the tubing has been properly cut, deburr it using steps 10 through 15 below.

CAUTION

DO NOT PLACE THE FITTING OVER THE TUBE END UNTIL THE TUBE END IS PROPERLY DEBURRED. DAMAGE TO THE FITTING MAY RESULT.

10. Inspect and assemble the correct deburring tool and stem subassembly using Table 2-1. Also refer to Figure 2-5 to complete steps 11 through 15 below.

Table 2-1. Deburring Tools and Stems

DEBURRING TOOL	TUBE OD (INCH)	TUBE WALL THICKNESS (INCH)	STEM SUBASSEMBLY REQUIRED
D9851	1/4	0.016 - 0.028	D9851-13-04
		0.028 - 0.050	D9851-13-03
	1/16	0.016 - 0.035	D9851-13-05
	3/8	0.016 - 0.035	D9851-13-06
		0.035 - 0.058	D9851-13-07
D9850	1/2	0.016 - 0.042	D9850-13-08
		0.042 - 0.065	D9850-13-09
	5/8	0.016 - 0.058	D9850-13-10
	3/4	0.016 - 0.065	D9850-13-12
D9849	1	0.020 - 0.083	D9849-13-06
	1-1/4	0.024 - 0.065	D9849-13-20
		0.065 - 0.109	D9849-13-21
	1-1/2	0.028 - 0.083	D9849-13-24

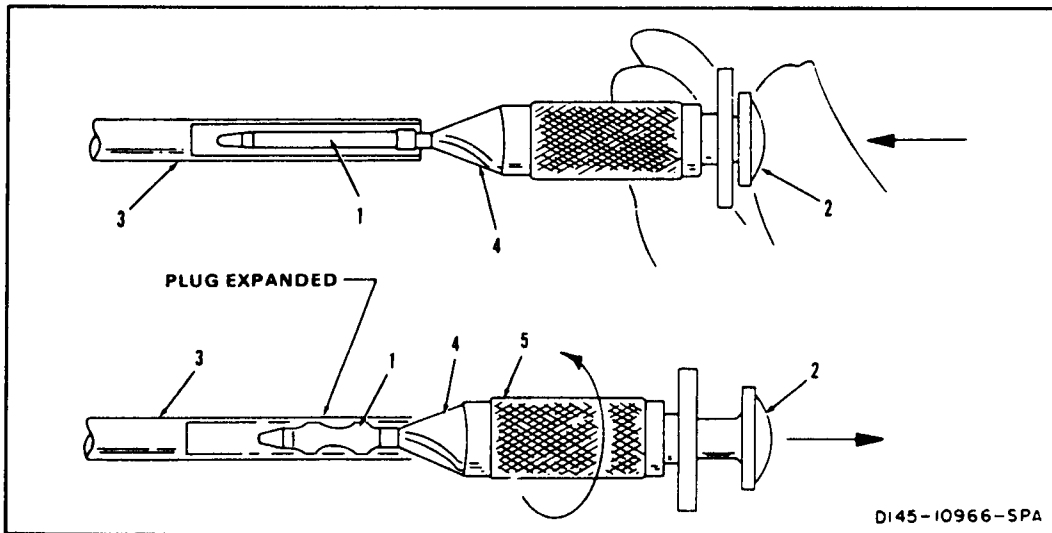


Figure 2-5. Deburring tool.

11. Lightly lubricate the plug (1) with hydraulic fluid (E199).
12. Press in the plunger (2). Carefully insert the tool into the tube (3) until the cutter (4) is approximately 1/8 inch away from the burr. Release the plunger (2) to allow the plug to expand and seal the tube.
13. Rotate the knurled body (5) of the deburring tool clockwise while applying slight pressure to the cutter (1). Continue to rotate until the cutter rotates smoothly, indicating the tube end is deburred. Do not cut too deeply into the wall of the tube. The width of the deburring chamfer should not exceed one-half of the wall thickness of the tube.
14. Without depressing the plunger, pull the tool from the tube (3) until the first bulge of the plug (1) is exposed. Wipe off the tube and plug. Inspect the tube end for proper deburring. Repeat step 13, if necessary.
15. Remove the deburring tool from the tube (3). Clean all chips from the tube and tool.

After the tube has been properly deburred, prepare the replacement tube. First select a piece of tubing; it must be the same size and length as the one being replaced. Then bend the replacement tube to the shape of the original tubing. Leave some excess tubing for the trim at both ends. Remove all burrs from the replacement tube (refer to steps 10 through 15).

CAUTION

DO NOT PLACE THE FITTING OVER THE TUBE END UNTIL THE TUBE END IS PROPERLY DEBURRED. DAMAGE TO THE FITTING MAY RESULT.

16. Trim the fitting end of the tube. Place the fitting over the tube to compare the length to the original fitting and tube.
17. Install the fitting onto the applicable component. Position the tube within the fitting, aligning the other end of the tube with the mating tube. Remove the tube, and trim the other end as required. The maximum gap allowed between mating tubes is 0.30 inch; see Figure 2-6 for types of mismatches and ways to handle them.

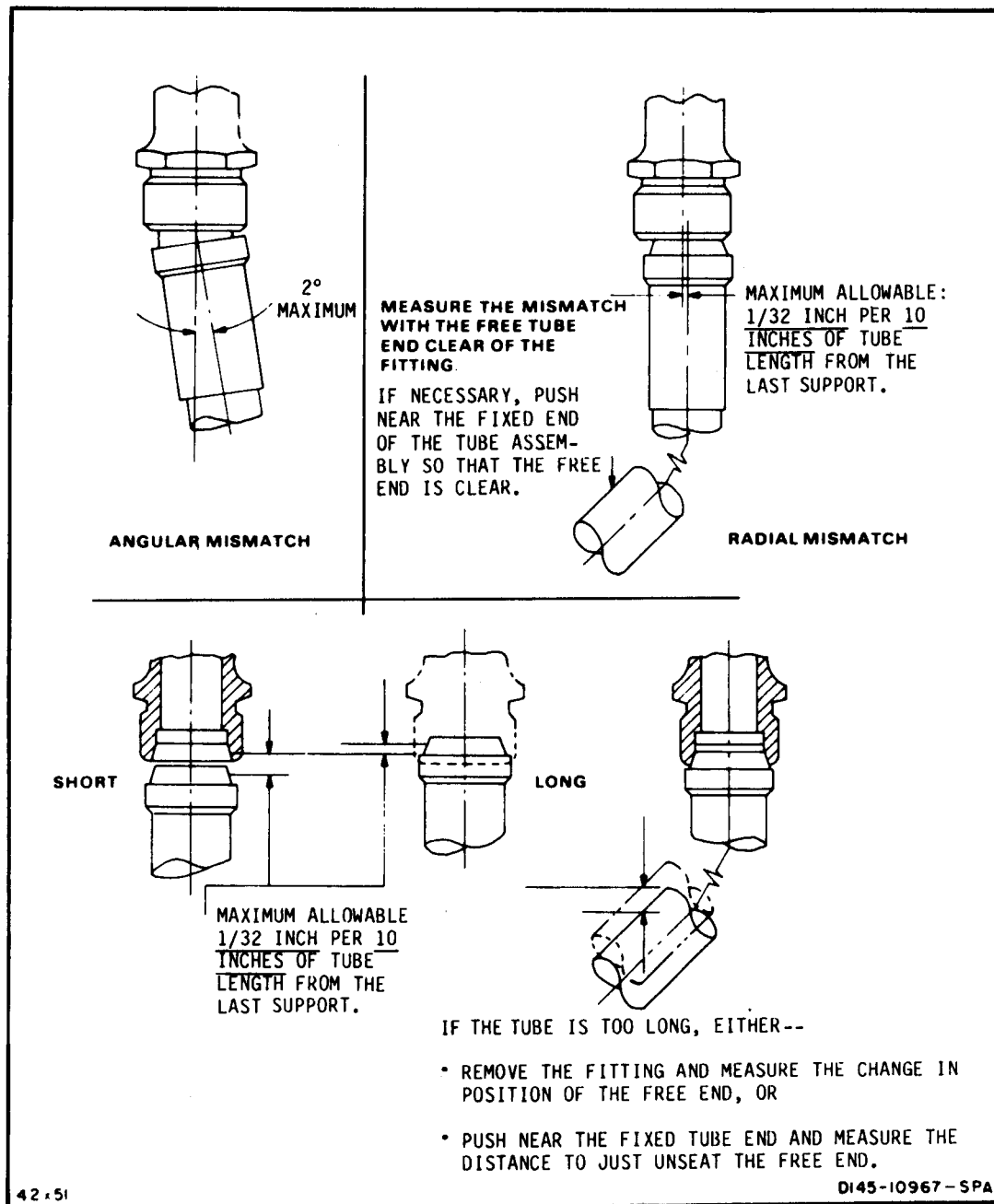


Figure 2-6. Types of mismatches.

After the replacement tube has been made, swage the tube using the permaswage repair procedure in steps 18 through 32 below.

18. Mark tube ends. Use the correct marking tool for the size of the tube to be swaged. When marking with tool 09862, place the lip stop against the end of the tube. (See Figure 2-7.) Using the slot as a guide, mark the tube in two places (180° apart) with the marking pen. If marking tool 09862 and marking pen D10058 are not available, see the chart in Figure 2-7 for the tube insertion band.

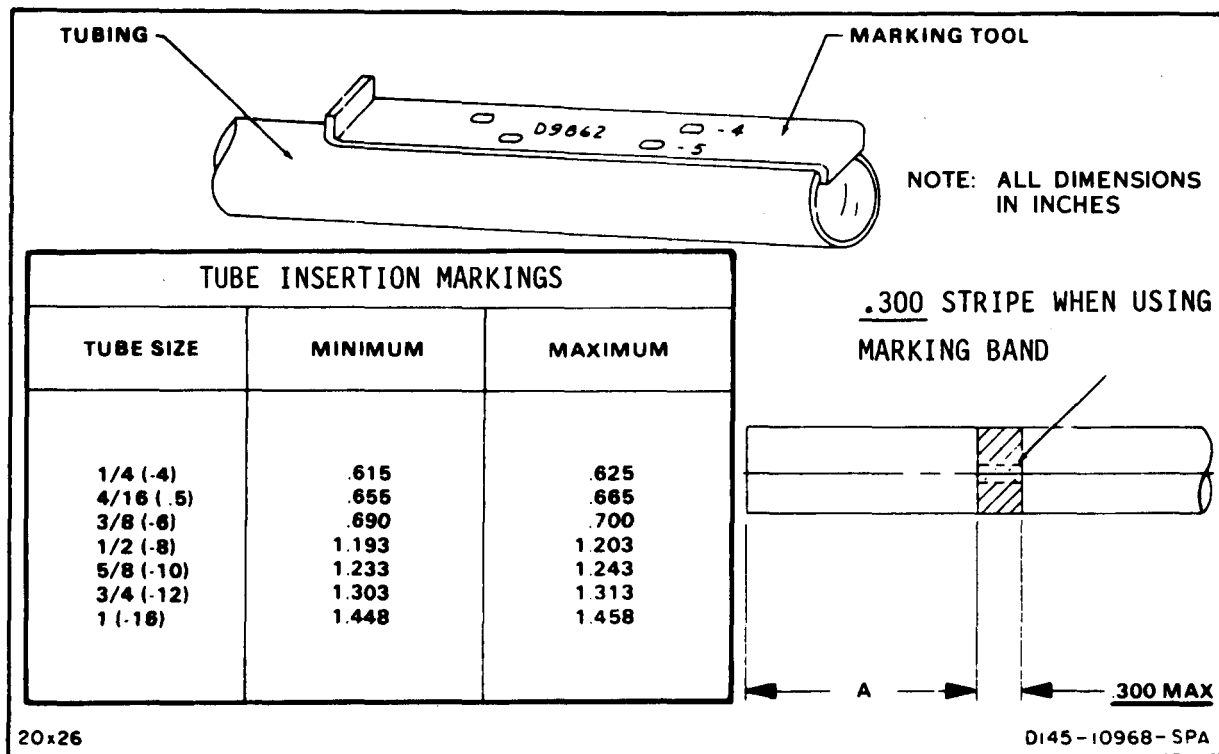


Figure 2-7. Marking tool and tube insertion markings/band.

19. Position the prepared tube within the fitting. Align the mating ends and position the union fitting. Check to see if the separable fitting can be swaged with the fitting installed on the component. If not, mark the fitting and tube so that proper clocking is obtained. Then swage the fitting off the aircraft using steps 20 through 32 below.
20. Connect the hydraulic pressure line from the portable hydraulic power supply to the fitting on the base of the swaging tool.
21. Set the selector valve on the power supply to EXHAUST to relieve all line pressure.
22. Install the set of die blocks in the swaging tool. Position the tool below the level of the power supply. These steps will

prevent air from getting in the hose and power supply. Cycle the power supply to 2,000 psi followed by EXHAUST; complete two or three cycles so all trapped air is bled from the cylinder.

NOTE: Some separable fittings are swaged without locators.

23. See Figure 2-8 for components of a hydraulic system and a chart of swage tool envelopes. Select the correct upper and lower die block assemblies for the size of the fitting to be swaged. Insert the lower die block with the correct fitting locator into the tool. When properly inserted, the fitting locator is on the opposite end of the tool from the latch.

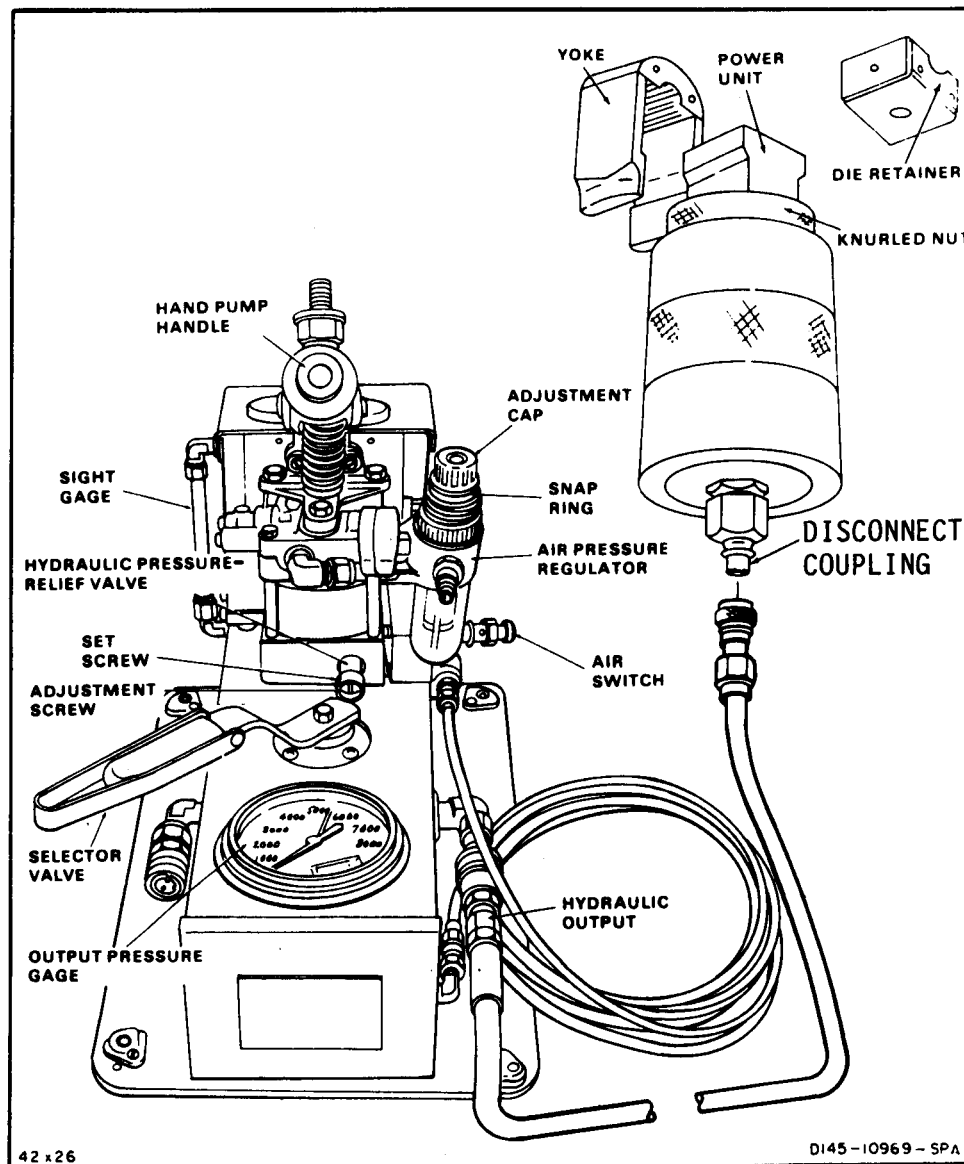


Figure 2-8. External and internal components of a hydraulic system and a chart of swage tool envelopes.

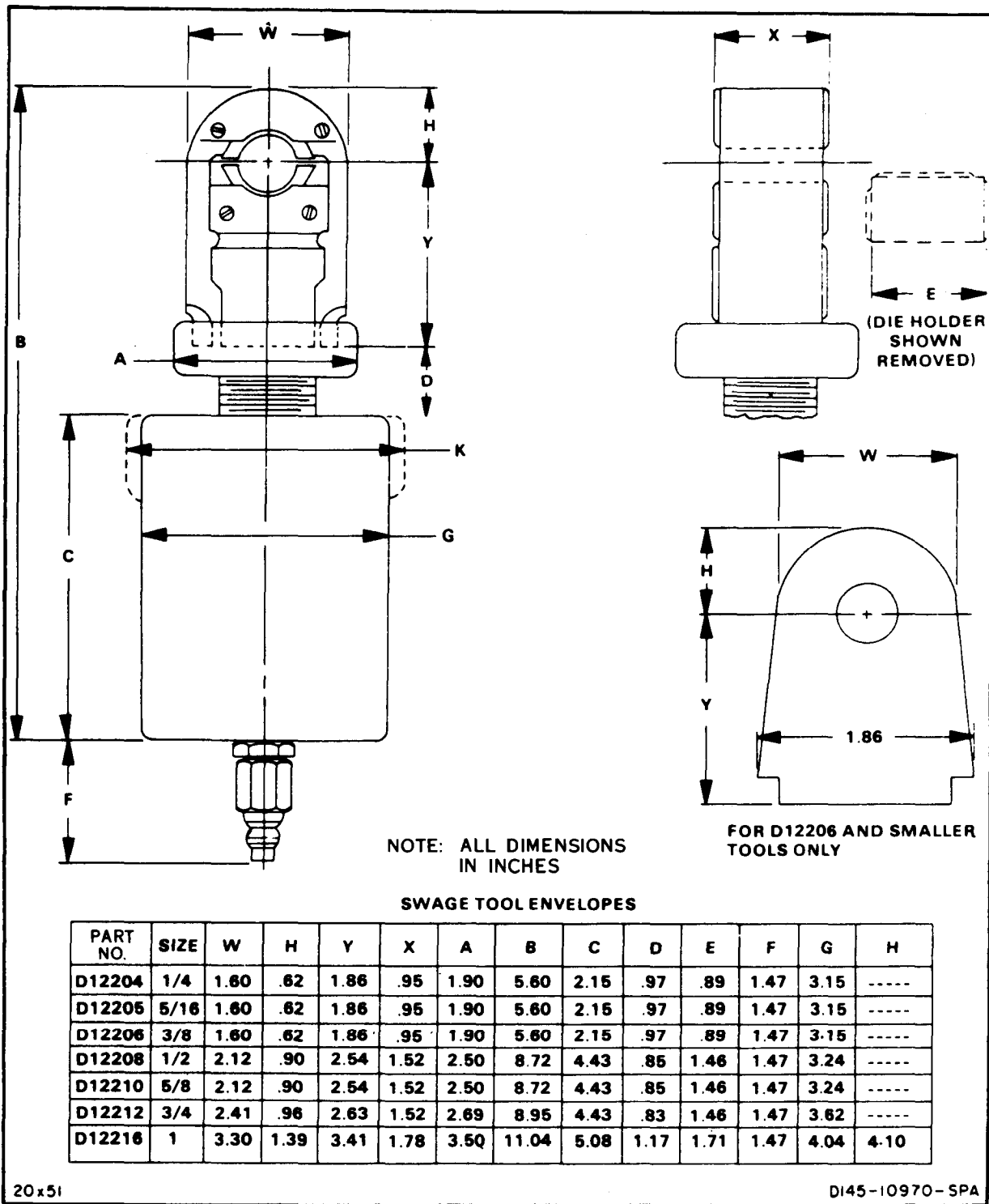


Figure 2-8. External and internal components of a hydraulic system and a chart of swage tool envelopes (continued).

24. Place the swaging tool and dies over the separable fitting. Make sure the fitting is positioned properly. Acceptable limits of tube insertion into the union are shown in Figure 2-9. Push up the latch to lock dies in place.

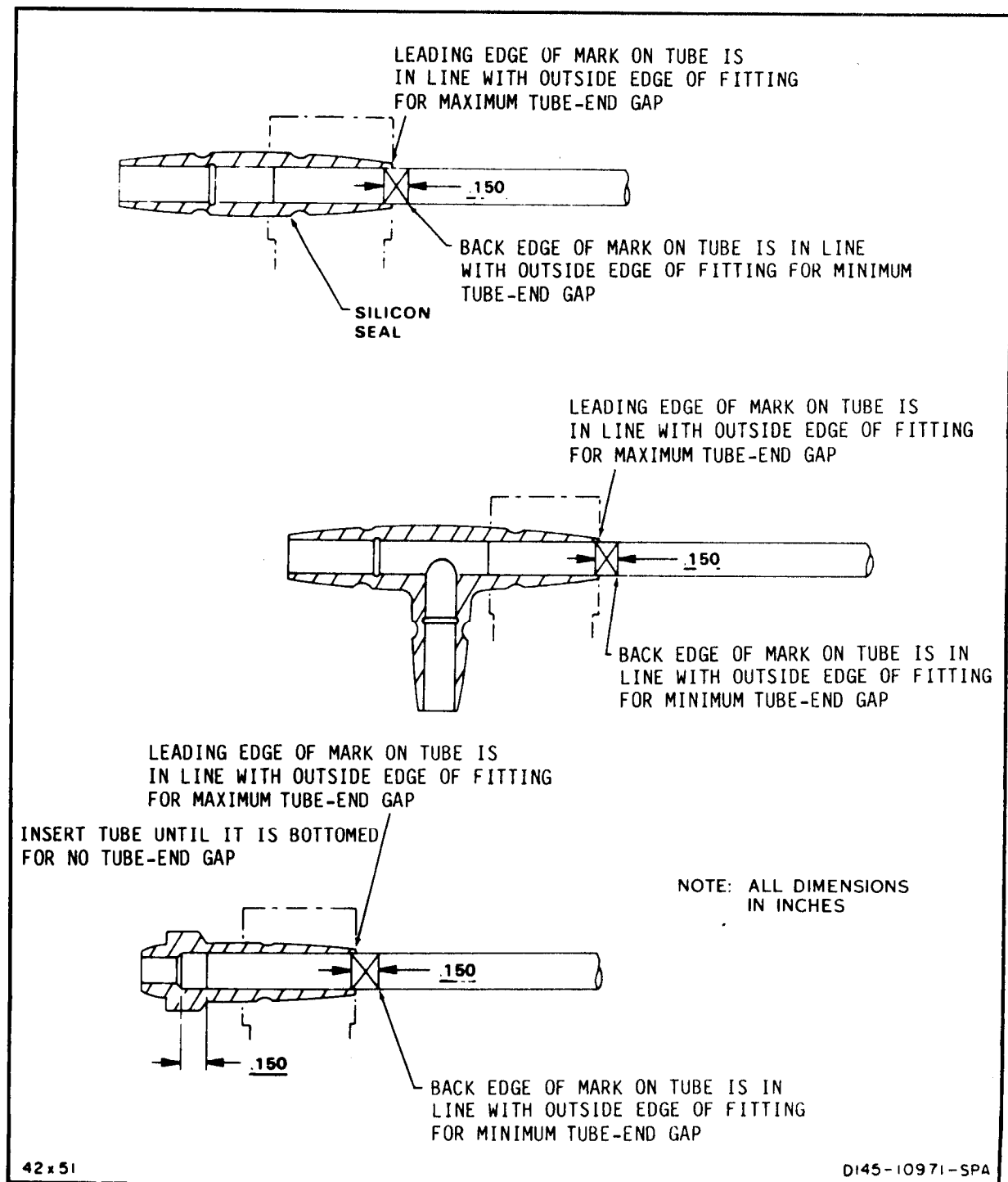


Figure 2-9. Acceptable limits of tube insertion into a union.

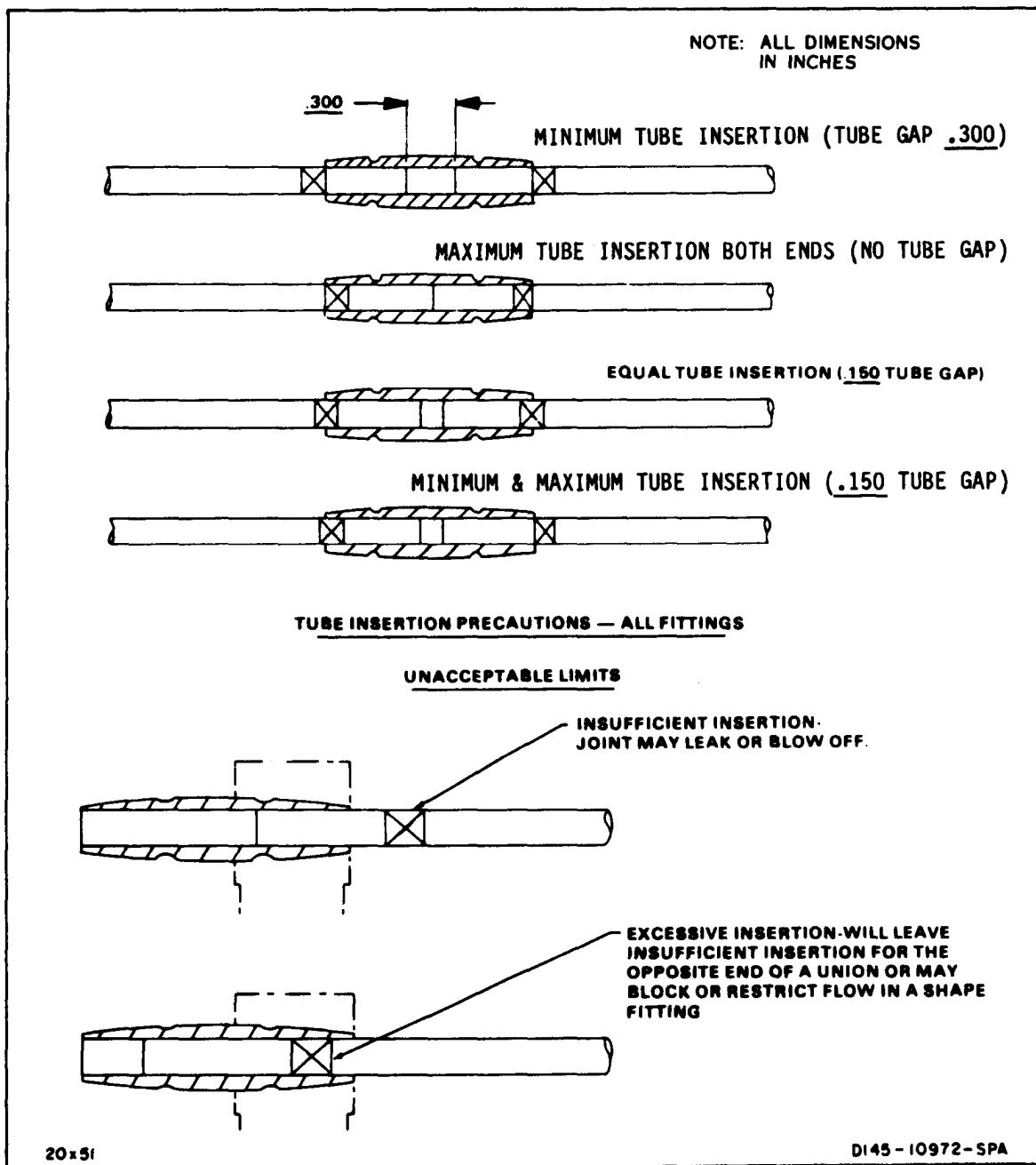


Figure 2-9. Acceptable limits of tube insertion into a union (continued).

25. Position the face of the swaging tool against the location mark on the tube. The outer edge of the latch must fall within the location mark. Tube insertion must be as shown in Figure 2-9.
26. Set the selector valve to the appropriate hydraulic output.
27. Actuate the swaging tool with 5,250- to 5,750-psi hydraulic pressure. If the shop air input is not available, use the hand pump.

28. Set the selector valve to EXHAUST to relieve the pressure completely.
29. Slide open the latch and remove the swaging tool from the swaged joint.

NOTE: Swaging dies make ridges on swaged fitting. Check after-swage dimensions between ridges.

30. Inspect the swaged end with the appropriate size go/no-go inspection gage according to the illustration in Figure 2-10. The fitting may be reswaged only once if the gage does not fit (repeat steps 24 through 30).
31. If the swaging operation was done off the aircraft, position and attach the separable fitting to the component. Align the mating ends and position the union fitting. Torque the fitting to its final torque; ensure the fixed portion of the fitting is held stationary.
32. With the union fitting positioned correctly, repeat steps 21 through 28 for both ends of the fitting.

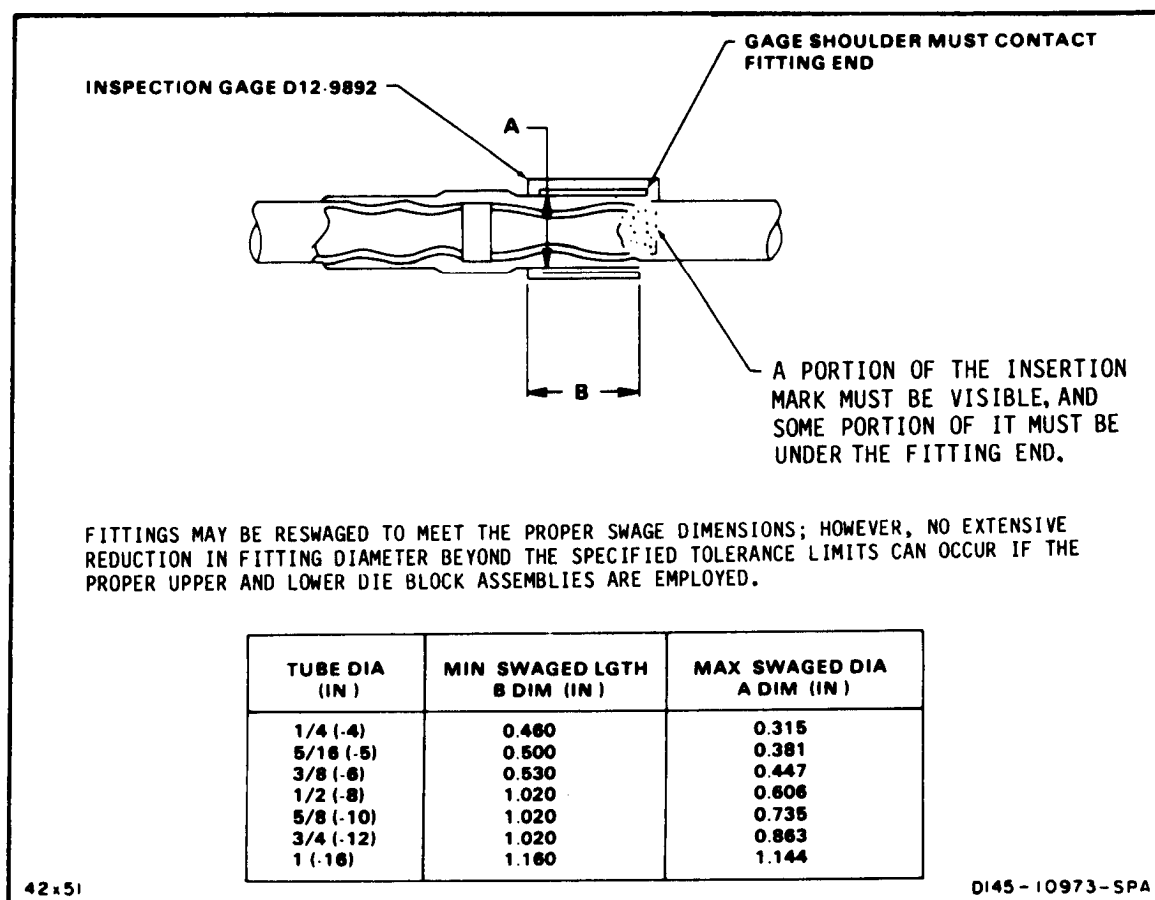


Figure 2-10. Measuring after-swage dimensions.

Flaring. The flaring tool used by the Army produces tubing flares with 74° angles. It produces a double-lap flare on 3/16- through 3/4-inch mild aluminum tubing and a single-lap flare on all grades of aircraft tubing, including 1/8-through 3/4-inch corrosion-resistant steel. When making flares, use the operating instructions furnished with the tool.

Single-flared tubing is used for tubing joints on all sizes of steel tubing, 6061 aluminum alloy tubing, and 5052 aluminum alloy tubing with more than a 1/2-inch outside diameter. Double-flared tubing is used for tubing joints on all sizes of 5052 aluminum alloy tubing with an outside diameter of 1/2 inch or less. Double flares are less apt to be cut by overtightening, and the tube assembly is less likely to fail under operating pressure. Refer to TM 55-1500-204-25/1 for more detailed information on bending and flaring tubing.

Installation.

Rigid Tube Assemblies. Before installing a rigid tube assembly in an aircraft, inspect it carefully and remove dents and scratches, if possible, without weakening the tube. Install the proper nuts and sleeves, and obtain a proper fit where the tubing is flared. Pressure-test the tube assembly to twice its operating pressure before installation. Ensure that the rigid tube assembly is clean and free of all foreign matter. Hand-screw the nuts to the mating connector, and then tighten therewith the proper wrench. Never use pliers. Avoid pulling the rigid tube assembly into place with the nut; line it up before tightening. Install rigid tubing that runs through cutouts with care so that it will not be scarred when it is worked through the hole. When the tubing assembly is long, tape the edges of any cutouts before installing the tubing.

Flared Tube Assemblies. After installing an aluminum alloy tube assembly and tightening to the required torque, check for leaks. If it leaks, do not tighten it any further. Overtightening can badly damage or completely cut off the tubing flare or damage the sleeve or nut. If the assembly is overtightened, disassemble the leaking connection and correct the fault. Undertightening connections can also be serious; it can cause the tubing to leak at the connector because of the insufficient grip on the flare by the sleeve. In this case, use a torque wrench to prevent undertightening. A nut should never be tightened when pressure is in the line; this could damage the connection without adding any appreciable torque. Common faults that cause leaking are--

- The flare is distorted into the nut threads.
- The sleeve is cracked.
- The flare is out of round.
- The flare is cracked or split.
- The inside of the flare is rough or scratched.

- The connector mating surface is rough or scratched.
- The connector threads or nuts are dirty, damaged, or broken.

If a steel tube assembly leaks, it may be tightened one-sixth of a turn beyond the normal torque to stop the leakage. If the assembly still leaks, it must be disassembled and repaired.

Flareless Tube Assemblies. When installing flareless tube assemblies, inspect them to ensure that they have no scratches or nicks and that the sleeve is properly preset. Lubricate the threads of the nuts and connectors with hydraulic fluid. Place the assembly in the proper position in the aircraft and finger-tighten clamps, brackets, supports, and nuts. The tubing ends should fit snugly in the connectors; little pressure should be required to hold them in place.

Tighten the nut by hand until you feel an increase in resistance to turning. If running the nut down with the fingers is impossible, use a wrench, but be alert for the first signs of bottoming. It is important that the final tightening start at the point where the nut just begins to bottom. With a wrench, turn the nut one-sixth of a turn (one flat on a hex nut). Use a wrench on the connector to stop it from turning while tightening the nut. Flareless tube fittings have no specific torque setting; therefore, use care when finding the exact point where the nut begins to bottom and when applying the required amount of turn on the nut.

After the tube assembly is installed, pressure-test the system. If a connection leaks, tighten the nut an additional one-sixth of a turn (making a total of one-third turn). If the connection still leaks after tightening the nut a total of one-third turn, remove the assembly. After removal, inspect the components of the assembly for scores, cracks, foreign material, or damage from overtightening. Overtightening a flareless tube nut drives the cutting edge of the sleeve deeply into the tube. This causes the tube to be weakened to the point where normal in-flight vibration could cause the tube to shear. After inspection (if no faults are found), reassemble the connections and repeat the pressure-test procedures. Do not in any case tighten the nut beyond one-third of a turn (two flats on the hex nut); this is the maximum the fitting may be tightened without the possibility of permanently damaging the sleeve and tube.

FLEXIBLE HOSE

Hose is used when flexibility is required in the connections between moving parts and where a line is subject to vibration. The hose is made of a flexible, leakproof inner tube and one or more layers of metal or fabric reinforcement braid. Rubber or teflon is used for making the flexible inner tubes. The type of material used for the reinforcement braid and the number of layers needed depend mostly on the pressure range of the hose. Medium and high pressure are the two range classifications in aircraft hydraulics. The medium range includes operating pressures of 1,500 psi and below; the high range includes pressures up to 3,000 psi.

Types. The two types of hoses are the rubber type and the teflon type.

Rubber Hose. The inner tube of rubber hoses used in aircraft hydraulic systems is made of synthetic rubber. Various compounds of rubber are used. Each compound provides a hose with some special capability, such as how it is used with certain fluids or how it operates within certain ranges of temperature. The kind of braid and the number of layers depend on the intended operating pressure range. The outer covering of most rubber hoses consists of wire, fabric, or rubber.

Bulk rubber hose has markings on its outer cover--in ink or paint or a metal tag--for identification. The information provided by the marking generally includes the identity of the manufacturer, date made, size, and military specification number. By referring to this number in a specification table in Chapter 7 of TM 55-1500-204-25/1, you can find additional information about the hose such as its pressure capability, its temperature limitations, and the fluids with which it may be used. On some hoses, a lay strip provides an easy method to determine whether an installed hose is twisted.

Rubber hose is used in aircraft hydraulic systems only as assemblies. An assembly is formed by attaching metal end connection fittings to each end of a section of bulk hose. A metal band around the assembly shows its national stock number, operating pressure, and pressure-test data. to Chapter 7 of TM 55-1500-204-25/1 for information on how to fabricate high- and medium-pressure assemblies.

Teflon Hose. Teflon is the registered trade name for tetrafluoroethylene, which is a synthetic resin. Teflon hose is widely used in Army aircraft. It offers the advantage of an unlimited shelf life in contrast to that of rubber hose.

Teflon hose has a flexible, leakproof inner tube reinforced with one or more layers of stainless steel braid. The size of the hose and the intended operating pressure determine the number of layers of braid that should be used. The outer covering is always of steel braid. Removable metal bands are placed along lengths of bulk hose for identification. These bands, usually made of brass, provide the military specification number, manufacturer's code number, and allowable operating pressure.

Teflon hose is used in aircraft hydraulic systems only as assemblies. A teflon hose assembly is identified by a permanently affixed stainless steel band. This band provides the national stock number, part number, and pressure-test date. Both medium-and high-pressure teflon hose assemblies are used in Army aircraft. Refer to TB 750-125 for information on how to fabricate teflon hose assemblies.

Installation. Before installation, visually inspect and pressure-test all field-fabricated hose assemblies. This applies regardless of whether they were just made or were previously made, tested, and placed in storage. Also pressure-test all factory- or depot-made assemblies before use. When connecting hose, remember--

- To lubricate fittings with hydraulic fluid before connecting the hose assemblies. Never connect dry fitting parts.
- To avoid making a straight hose connection between two rigid connection points. Allow slack of at least 5 percent of the hose length for operation and shrinkage.
- To add 5 percent to the hose length when installing a hose with only a slight bend. Where a hose is attached to an engine-mounted hydraulic component, provide hose slack of at least 1 1/2 inches between the component and the hose support nearest the engine.
- To tighten fittings to exact torque specifications given in the applicable technical manuals. Avoid guesswork.
- To visually check for backed-out retaining wires on swivel nuts.

Teflon hose requires a different kind of support than that of rubber hose; however, the following principles apply to both rubber and teflon hose:

- Supports should be spaced in 24-inch intervals or closer, depending on the size of the hose.
- A hose assembly connecting two rigidly mounted fittings must be supported firmly but not rigidly.

To protect the hose against damage from chafing, provide adequate clearance between the hose and other objects. For example, use grommets to protect the hose passing through bulkheads. The hose must also be protected from extreme temperatures. For example, shrouding or relocating the hose provides protection from engine exhaust and hot engine parts.

Vibration is harmful to hose. When a hose is connected to a unit that moves in a direction opposite to the movement of the airframe, install the hose with slack between the last point of support and the movable unit. The slack must be great enough to prevent the hose from being pulled off its end fittings. However, the hose must be firmly supported to eliminate vibration-caused strain on the hose connection.

Hydraulic lines in Army aircraft are identified by color-coded tape applied in one of two ways. In some aircraft, the word HYDRAULIC is printed on blue tape running along the line; circles applied to the tape further identify the lines as hydraulic ones. In other aircraft, three 1/4-inch-wide bands of tape colored blue, yellow, and green are spaced one-sixth of an inch apart to identify the hydraulic lines. With either system, additional white tape with arrows printed on it to indicate direction of flow may run adjacent to the colored tape to identify a pressure line or a return line.

HYDRAULIC FITTINGS

Hydraulic fittings are used throughout the hydraulic system to provide simple connections between hydraulic components and tubing. Standard MS

(flareless) and AN (flared) fittings are used in Army aircraft. Both types are made in many different shapes and designs. They may be ordered in either male or female designs or in combination designs (male on one end and female on the other). The hydraulic repairer is concerned with installing both the AN and MS fittings in aircraft hydraulic systems. Normally the fittings are selected according to the design of the system. The hydraulic repairer repairs fitting failures by duplicating the original installation.

Flareless Fittings (MS). These fittings are used to connect unflared tubing. They have a counterbore in which the tube end is installed. Figure 2-11 shows a half-sectional view of an MS fitting. Notice the 24° beveled portion of the counterbore and its seat. The seat forms a slope for the tube during the connection of one tube to another or of a tube to a component. The beveled area causes the tube connector sleeve to seal the connection as the tube B-nut is tightened. See Figure 2-12 for an MS fitting properly installed.

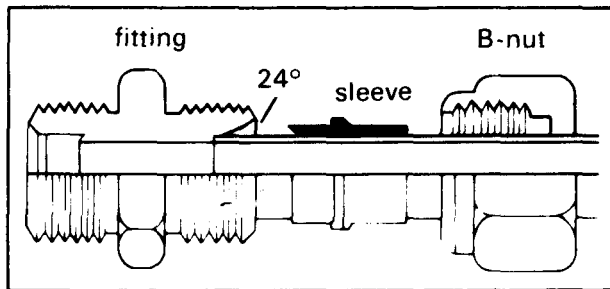


Figure 2-11. Half-sectional view of an MS fitting.

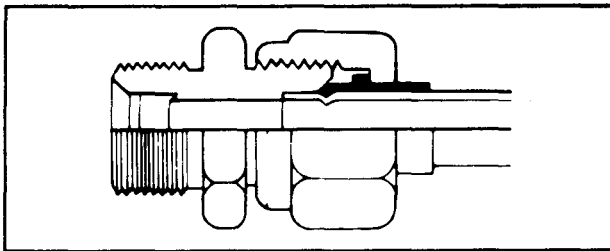


Figure 2-12. MS flareless fitting installed.

Identification. MS fittings are made of aluminum alloy or steel. Aluminum alloy fittings can be identified visually by their yellow color, which is caused from the anodizing treatment. The cadmium plating on steel fittings gives them a silvery white color. MS fittings are identified by letter-number codes; for example, MS21900-4 is interpreted as follows:

- MS.....prefix (military specification)
- 21900..design part number (adapter, flareless tube to AN flared tube)
- 4.....size of fitting in sixteenths of an inch (4/16 inch)

The material from which the fittings are made is indicated by the absence of a letter at the end of the MS number or by the addition of a letter at the end of the number; for example--

MS21900-4 is made from carbon steel.

MS21900-8-D is made from aluminum alloy.

MS21900-8-S is made from corrosion-resistant steel, Class 347.

Types. MS fittings may be procured in many styles. See Figure 2-13 for an MS21904 elbow with a 90° angle. The fitting is used where the routing of tubing requires a 90° change in direction in a limited area. The flat surface between the threaded ends allows an open-end wrench to be used to hold the fitting in position while tube connections are being made.

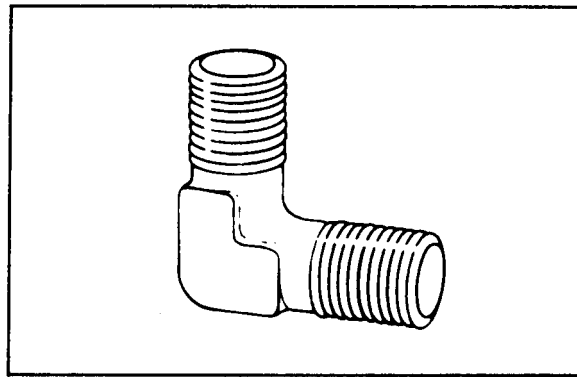


Figure 2-13. MS21904 elbow with a 90° angle.

The MS21905 tee (Figure 2-14) and the MS21906 cross fitting (Figure 2-15) connect common-purpose lines that come together within the hydraulic system. They, like the 90° fittings, have flat surfaces where an open-end wrench may be placed to assist in maintaining the fitting in the correct position.

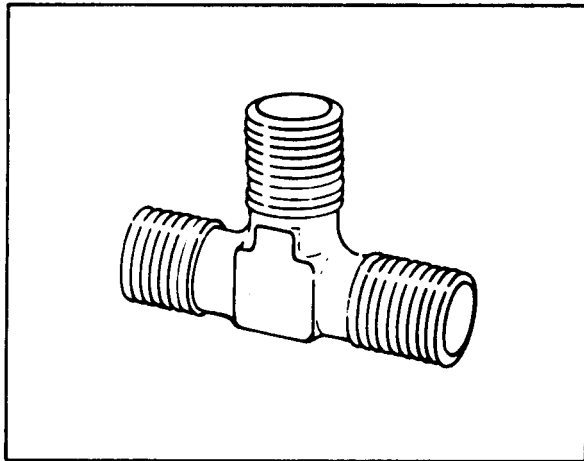


Figure 2-14. MS21905 tee.

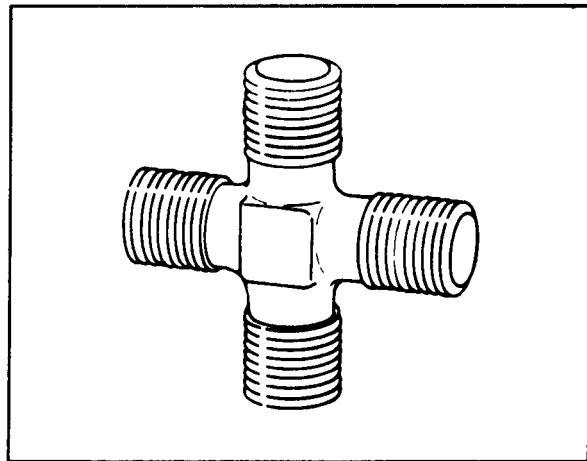


Figure 2-15. MS21906 cross fitting.

At times, it may be necessary to reduce or expand a hydraulic connection. An MS21916 reducer (Figure 2-16) is normally used in the first case, and an MS21915 bushing (Figure 2-17) in the latter. Both bushings and reducers are usually necessary when connecting components to hydraulic test equipment.

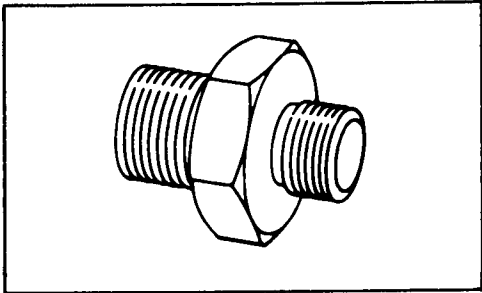


Figure 2-16. MS21916 reducer.

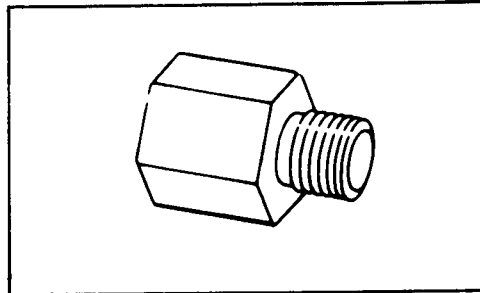


Figure 2-17. MS21915 bushing.

The MS21902 flareless tube union (Figure 2-18) is used for straight connections of tube to tube or tube to component.

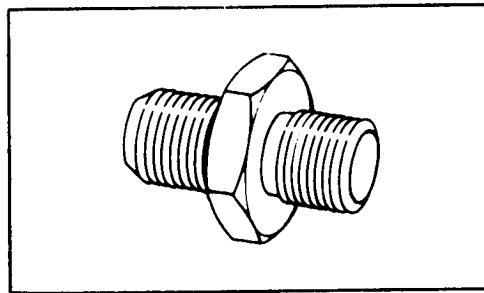


Figure 2-18. MS21902 flareless tube union.

Plugs MS21913 (Figure 2-19) and caps MS21914 (Figure 2-20) should be used whenever any aircraft undergoing maintenance has a line or component disconnected that is not to be reconnected immediately. These fittings prevent loss of hydraulic fluid or entrance of foreign matter whether the system is in a static or a pressurized condition. MS plugs are used on any MS female connector of corresponding size. MS caps are used on all MS male fittings of the same size.

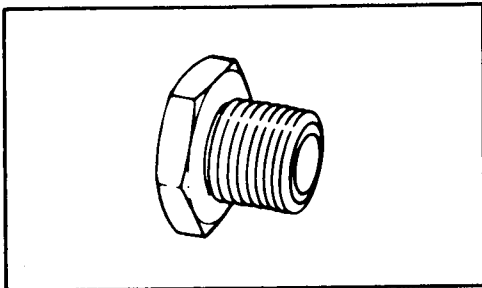


Figure 2-19. MS21913 plug.

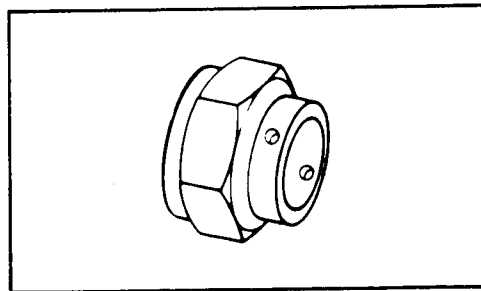


Figure 2-20. MS21914 cap.

Installation. MS fittings must be inspected before installation. Sometimes it is impossible to see through a fitting or tube; in this case, blow clean, dry, compressed air through it to be certain that no obstructions exist. Any lines that have caps removed in storage or before installation should be flushed with clean hydraulic fluid. Male threads and sleeves of the fittings being assembled should be lubricated with the same hydraulic fluid used in the system. On fittings with tapered threads, use antiseize compound on the threads except for the first three, which are left dry.

To make a connection between the tubing and a component, select, lubricate, and install the proper gasket in the position shown in Figure 2-21. Screw the fitting into the boss of the component until it bottoms on the boss. (See Figure 2-22.)

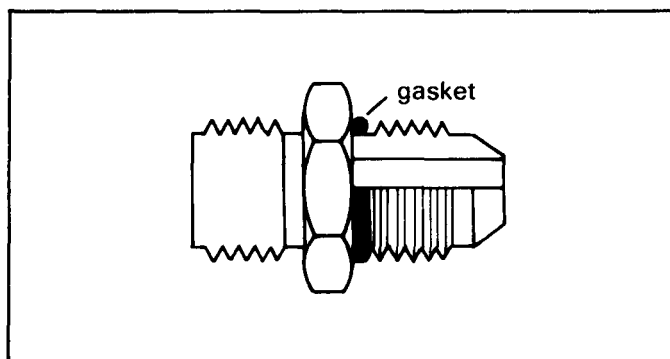


Figure 2-21. MS fitting with gasket.

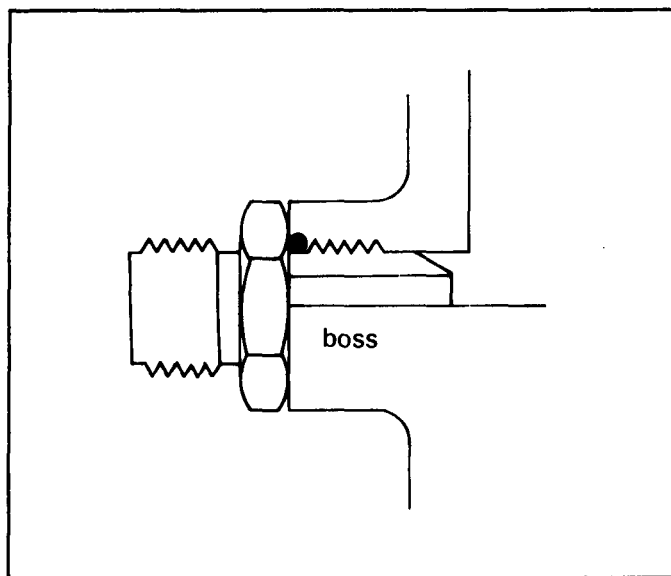


Figure 2-22. MS fitting screwed into the boss.

When tubing is connected to an MS fitting, align the tube with the fitting, and start the nut by hand without excessive strain on the line. Do not use force to align tubing. Align the tube by loosening clamps on

connecting lines or by rotating fittings. (See Figure 2-23.) Connect both ends of the tubing, and tighten them until an increase in resistance to turning is encountered in the B-nut. At this point, tighten the clamps and ensure that they do not pull the tubing out of alignment; place clamps in a binding position. Complete the installation by turning the B-nut one-sixth of a turn. Pressurize the hydraulic system and inspect for leaks. If leakage is noted, release system pressure and back off (loosen completely) the B-nut. If possible, rotate the sleeve to a new position, and then retorque the B-nut to its previous position plus one-sixth of a turn. Normally this action will stop the leak; if it does not, replace the assembly.

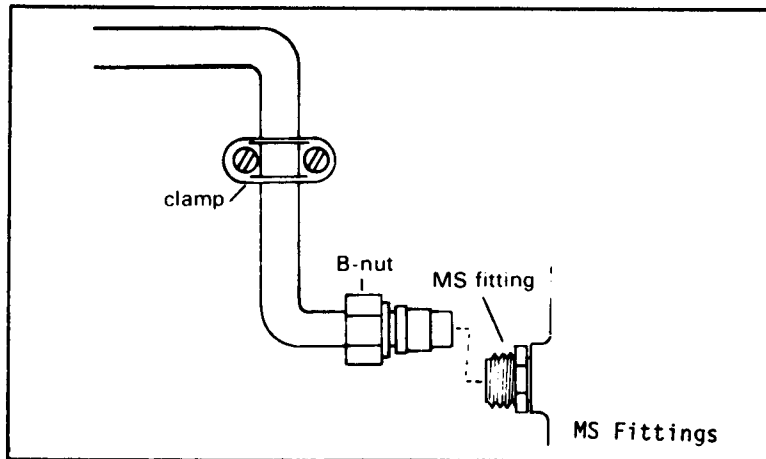
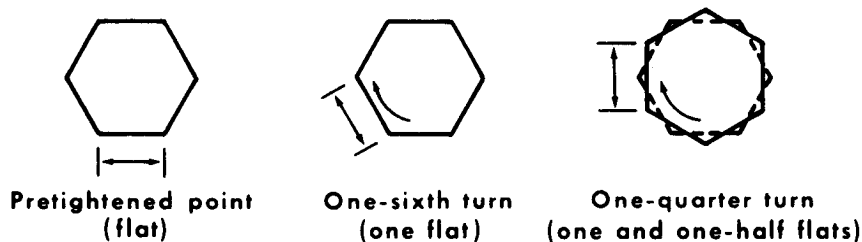


Figure 2-23. Alignment of tubing.

When connecting tubing to an MS fitting, refer to Table 2-2 for the torque and flat-turn values for nuts on flareless tubing.

Table 2-2. Torque and Flat-Turn Values for MS Fittings



Tubing	Size	Torque (inch-pounds)	Tightening - Rule of Thumb (Flat Turns after Pretightening)	
			Normal tight	Extra tight
Aluminum or steel	- 3	65 to 95		2 Maximum
	- 4	100 to 150	1 to 1 1/2	2 Maximum
	- 6	175 to 300	1 to 1 1/2	2 Maximum
	- 8	325 to 500	1 to 1 1/2	2 Maximum
	-10	400 to 700	1 to 1 1/2	2 Maximum
	-12	500 to 800	1 to 1 1/2	2 Maximum
	-16	500 to 800	1 to 1 1/2	2 Maximum
Aluminum	-20	600 to 900	1 to 1 1/2	2 Maximum
	-24	600 to 900	5/6 to 1	1 1/2 Maximum

To make a tube-to-tube connection, tighten the tube B-nut until a definite resistance is felt; then turn it one-sixth of a turn farther. The upper wrench is held stationary while the lower wrench is moved upward until the B-nut is tightened a sufficient amount. (See Figure 2-24.) On this tube connection, like most others, paint a 1/8-inch colored stripe across the completed assembly so that loosening can readily be detected. (See Figure 2-25.)

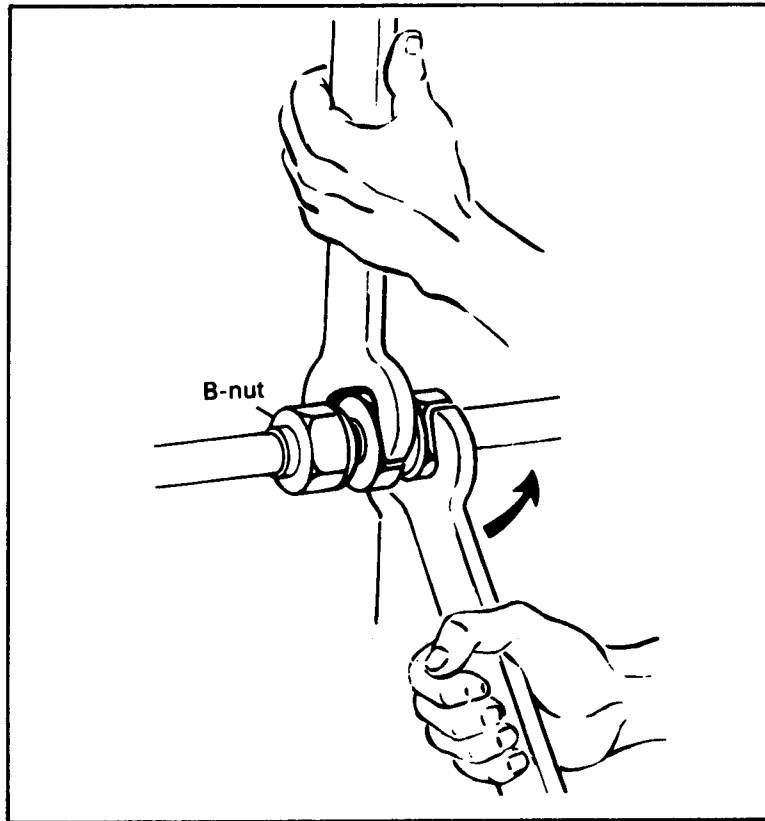


Figure 2-24. Tightening an MS fitting.

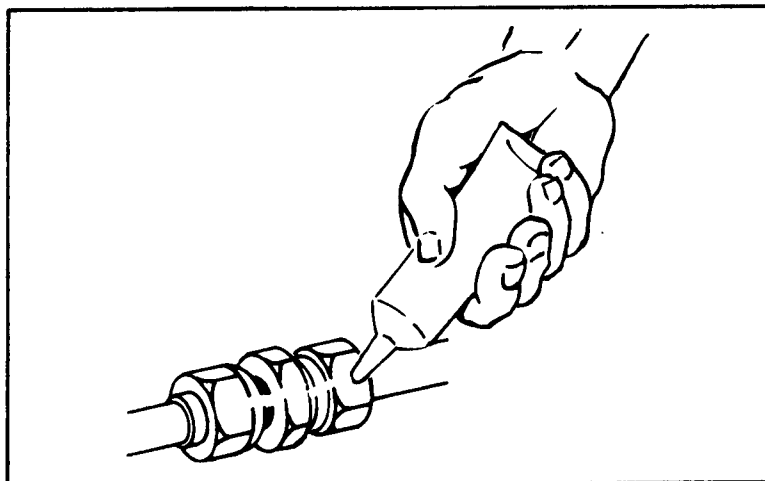


Figure 2-25. Marking an MS fitting.

Flared Fittings (AN). Flared fittings, like flareless (MS) fittings, come in many different shapes. They are easily identified by their distinguishing colors; aluminum alloys are blue, and steel alloys are black. Aluminum-bronze fittings are cadmium-plated and are not otherwise colored. Only steel fittings are used with steel tubing (3/8-inch outside diameter and smaller); other fittings and tubing can be intermixed. The main difference between AN and MS fittings is the manner in which the hydraulic tube fits to the fitting. The MS fitting has a counterbore in which the tubing is inserted; the AN fitting has a 37° flared (beveled) face to which the tubing is fitted. (See Figure 2-26.) This flared area of the fitting is the sealing surface and must be maintained. Any bad flare on this sealing surface will show up as a hydraulic leak.

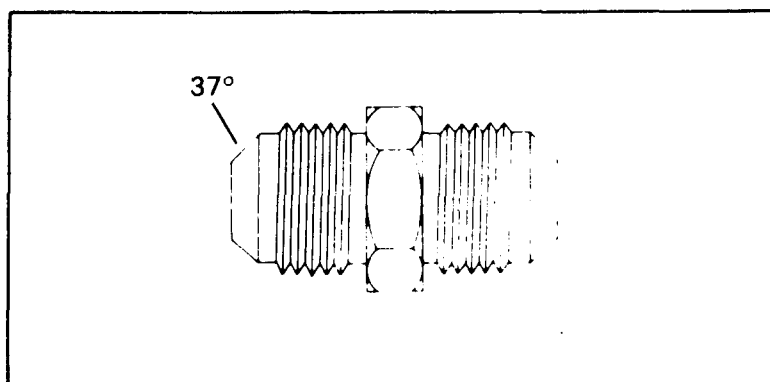


Figure 2-26. Standard AN fitting (union).

Identification. Standard AN fittings used in Army aircraft are manufactured from aluminum alloy and steel. For identification only, aluminum alloy fittings are blue; carbon steel fittings are black; and cadmium-plated fittings are silvery white. Like MS fittings, AN fittings are identified by letter-number codes; for example, AN6289-4 is interpreted as follows:

ANprefix (Army-Navy)

6289design part number (nut)

4size of fitting in sixteenths of an inch
(4/16 inch)

The material from which flared fittings are made is indicated by the absence of a letter between the design part number and size number or by the addition of a letter at this location; for example--

AN6289-4 is made from carbon steel.

AN6289-D-4 is made from aluminum alloy.

AN6289-S-4 is made from corrosion-resistant steel, Classes 304L and 347.

Installation. Standard AN fittings are installed the same as MS fittings with the exception of the B-nuts and sleeve installation. Like the MS fittings and tube assemblies, the AN fittings and tube assemblies must be inspected before installation. Ensure that the sealing surface of the fitting to which the tube will be attached is free of scratches, cuts, burrs, nicks, and other imperfections that might prevent a leakproof connection.

Before installation, lubricate all male fittings and the outside of the tube flare and sleeve with the same type hydraulic fluid used in the system. During installation, ensure that the tube assembly is aligned and that the B-nut starts by hand. The nut should be fitted and started with at least three full turns to prevent cross-threading. All B-nuts should be tightened until a slight resistance is felt. From this point, where possible, B-nuts should be tightened with a torque wrench to the values specified in Table 2-3.

Table 2-3. B-Nut Torque Values

TORQUE ON TUBE NUT		
TUBE OUTSIDE DIAMETER	ALUMINUM ALLOY TUBING	STEEL TUBING
1/4 INCH	40-65 INCH POUNDS	135-150 INCH POUNDS
5/16 INCH	60-80 INCH POUNDS	180-200 INCH POUNDS
3/8 INCH	75-125 INCH POUNDS	270-300 INCH POUNDS
1/2 INCH	150-250 INCH POUNDS	450-500 INCH POUNDS
5/8 INCH	200-350 INCH POUNDS	650-700 INCH POUNDS
3/4 INCH	300-500 INCH POUNDS	900-1,000 INCH POUNDS
1 INCH	500-700 INCH POUNDS	1,200-1,400 INCH POUNDS

If flared connections leak, disconnect the fitting and inspect the sealing surfaces. If no faults exist, check the tube assembly for misalignment. A correctly torqued fitting is shown in Figure 2-27.

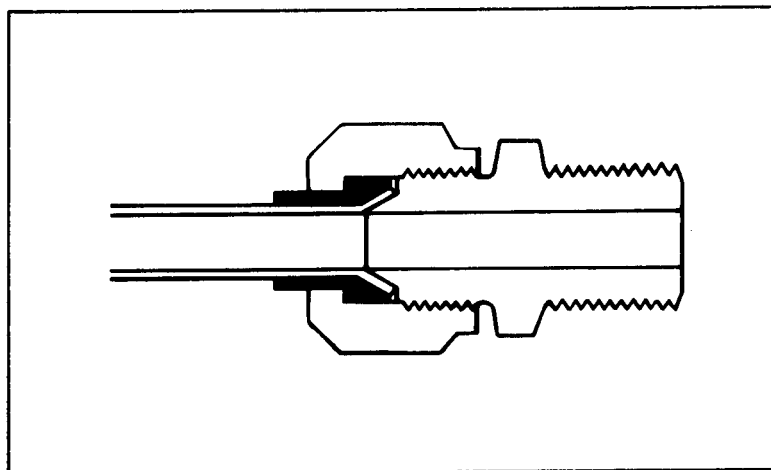


Figure 2-27. Properly torqued flared fitting.